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ABSTRACT

This study was designed to investigate whether the implementation and integration of the use of the Explorer Calculator into the curriculum influenced students in grades three through six. The sample consisted of approximately 440 students who were assigned to the treatment group or the control group. Achievement scores from the Iowa Test of Basic Skills (ITBS) and Mathematics Measurement Instrument were used as pre- and post-test data. Tables are presented showing the pre- and post-test means by grades and groups in mathematics areas, such as overall achievement, computation skills, concept development, and problem solving abilities. Data from both tests showed consistent improvement for the two groups. The students receiving the calculator treatment performed as well as the non-calculator group on these measures. After discussing some limitations of this research design, four recommendations were made based on the results. (YP)

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USING THE EXPLORER CALCULATOR IN MATHEMATICS EDUCATION IN GRADES THREE THROUGH SIX

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a report

prepared for the

College Station Independent School District

by

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USING THE EXPLORER CALCULATOR IN MATHEMATICS EDUCATION IN GRADES THREE THROUGH SIX

During the past fifteen years, a considerable amount of material has been written in support of the use of calculators in the teaching of mathematics. Research has supported the use of the calculator for promoting achievement, improving problem solving skills, and increasing the understanding of mathematical concepts.

The National Council of Teachers of Mathematics (NCTM) has just published the Curriculum and Evaluation Standards for School Mathematics. This first-of-its-kind statement of standards for teaching is expected to be the guideline for teaching mathematics for the next several years. The support of technology including calculators and computers occurs throughout these "Standards." The Texas Education Agency also supports the use of the calculator in the classroom. This support is reflected in the development of five inservice modules on the use of the calculator and computer in grades Pre-kindergarten through grade 10.

Even with the empirical support for applying calculators to classroom instruction, little effort has been made to integrate the use of the calculator into the curriculum. In addition, published reports on the use of the Texas Instrument Explorer Calculator which is the calculator to be used in this study in classrooms is nonexistent because it has been available for such a brief period.

Background Information for this study

In September, 1988, a presentation was made at the College Station Independent School District Board meeting. The thrust of the presentation was to acquaint the Board with a developmental project in grades 3 through 6 which would result in an inservice training module for teachers on the proper use of calculators in the teaching of

mathematics in these grade levels. Approval was obtained for that project and, as a result, the school administration requested a modest research study. C.J. Dockweiler, Professor of mathematics education at Texas A&M University, agreed to conduct the study and report the results to the District.

The previously mentioned developmental project was a funded project through the Texas Education Agency. The project provided the Texas Instrument calculators for the project with the understanding that the calculators would be removed from the classrooms at the completion of the project. It was, therefore, deemed appropriate to conduct a study to gather some information regarding the impact of calculator use on the student achievement of the targeted grades.

Statement of the Research Problem

The study was designed to investigate whether the implementation and integration of the use of the Explorer Calculator into the curriculum influences computational skills, concept development, problem solving abilities, and overall mathematics achievement of students in grades three through six.

Research Questions:

1. Do students in classes in which calculator use has been integrated into the mathematics curriculum exhibit comparable overall achievement gains in mathematics as do students in classes in which calculators have not been used?
2. Do students in classes in which calculator use has been integrated into the mathematics curriculum exhibit comparable mathematics achievement in the areas of concept development, problem solving, and computational skills as do students in classes in which calculators have not been used?

Sample

The sample consisted of approximately 440 third, fourth, fifth, and sixth grade students. The treatment group (those using calculators) included about 220 students from ten classrooms; three third grade classes, three fourth grade classes, two fifth grade classes, and two sixth grade classes. The control group (no calculator use) was of similar size, 220 students and 10 classrooms and grade placement.

Procedures

Prior to any significant calculator activity, all participating students were administered a grade level Mathematics Measurement Instrument (December, 1988). This test was developed to reflect the curricular requirements in mathematics and was administered to both groups as a pre-test. In early May, the Mathematics Measurement Instrument was administered again to all students as a posttest.

Additional achievement data was obtained from the Iowa Test of Basic Skills (ITBS) which the District uses as their standardized test of achievement. The results from the 1988 administration of the ITBS have been compared with the results of the 1989 administration.

The teachers of the treatment group classes met frequently during the school year to discuss the use of the calculators and the integration of these ideas into the mathematics program. The teachers also considered and developed various activities which could be productively used with students. These activities were then used with their students.

Review of Related Literature

A major difficulty in calculator research is a lack of the implementation and integration of calculator use into the curriculum. Presently, most calculator research deals only with particular topics and selected portions of mathematics at given grade levels.

Research regarding the effects of calculator usage upon the attainment of computational skills dates back to the mid-seventies. Results of studies vary considerably. Nelson (1976) reported that gains in basic computational skills can be significantly improved when students in grades four through seven utilize calculators. An investigation by Albina (1981) supports this idea as do many other studies (e.g., Spencer, 1974; Brey, 1980; Miller, 1977). Many studies reported no significant differences, yet concluded that the use of calculators with mathematics instruction will improve computational skills (e.g. Wilson, 1978; Channel, 1979). In grade four, contradicting reports were reviewed. Eckmier (1978) wrote that although significant differences were not found, the use of the calculator does not interfere with the ability to compute, to understand concepts, or to solve problems. However, in a meta-analysis, Hembree (1984) claimed that sustained calculator usage in grade four can negatively effect students' basic skills.

Abo-Elkhair (1981) supported the use of calculators for the acquisition of the basic concepts of average. Burnett (1985) and Allen (1976) also reported that the use of the calculator is effective for developing mathematical concepts. Eckmier (1978) and Sutherlin (1976) found no significant differences in the development of mathematical concepts, yet supported calculator use for this purpose.

Spencer (1974) found significant differences in favor of the calculator group with regard to reasoning ability. In the results of his meta-analysis. Hembree (1984) claimed that the average student's basic skills with paper and pencil in problem solving improve through calculator usage. Results of a study by Kelly (1984) supported the conclusions that the calculator can enhance the use of deductive reasoning, the ability of students to explain and implement their strategies, and the abilities of students to effectively use

solution evaluation techniques. Stewart (1980) and Kasnic (1977) also supported calculator usage in problem solving.

Data Analysis and Results

For each data set at each grade level the 1988 and 1989 ITBS data were analyzed by a t-test. That is, the third grade control group results were analyzed by a t-test to see if the 1989 mathematics results on the ITBS were significantly different from the 1988 results. This analysis was done for the Mathematics Total of the ITBS as well as the sub-scores which were provided. Similarly, the third grade treatment group results were analyzed by a t-test to see if the 1989 mathematics results were significantly different from the 1988 results. Observations could then be made about comparable gains of the control group and the treatment group. The ITBS, as a standardized achievement test is designed to measure achievement gained over a year's period.

The second major data set was obtained from the Mathematics Measurement Instrument. This instrument was administered as a pre- and post-test and the data would more likely be influenced by the treatment. The overall score and sub-scores were analyzed by a t-test in a similar way as described previously for the ITBS.

The results from the ITBS data are shown in Tables 1 through 8. ITBS data are reported as a total score (Math Total) and also the results are broken down into sub-scores (Concept Development, Problem Solving, and Computational Skills).

For all grades and for each total score or sub-score the gains are reported to be statistically significant (p.1). As the Control and Treatment results are scanned, it becomes apparent that the results are very comparable. The Control groups and the Treatment groups have achieved comparable gains.

Table 1
3rd Grade - Control - ITBS
(N = 40)

Math Area	'88 Mean	'89 Mean	T	Prob.
Math Total	101.975	109.7500	-7.42	0.000
Concept Dev.	105.100	112.7500	-4.28	0.000
Prob. Solv.	98.725	108.9250	-5.89	0.000
Comp. Skills	102.775	108.0750	-4.11	0.000

Table 2
3rd Grade - Treatment - ITBS
(N = 49)

Math Area	'88 Mean	'89 Mean	T	Prob.
Math Total	104.2041	112.6531	-9.01	0.000
Concept Dev.	106.1429	115.2449	-6.00	0.000
Prob. Solv.	105.6735	113.2449	-2.80	0.007
Comp. Skills	103.4694	110.1837	-5.77	0.000

Table 3
4th Grade - Control - ITBS
(N = 51)

Math Area	'88 Mean	'89 Mean	T	Prob.
Math Total	114.2157	126.6078	-10.29	0.000
Concept Dev.	116.9804	131.9020	-9.85	0.000
Prob. Solving	114.9216	126.9020	-6.88	0.000
Comp. Skills	110.9216	121.1961	-6.55	0.000

Table 4
4th Grade - Treatment - ITBS
(N = 50)

Math Area	'88 Mean	'89 Mean	T	Prob.
Math Total	114.02	125.960	-12.70	0.000
Concept Dev.	116.94	130.960	- 8.01	0.000
Prob. Solving	113.14	125.140	- 8.25	0.000
Comp. Skills	111.96	121.180	- 8.11	0.000

Table 5
5th Grade - Control - ITBS
(N = 26)

Math Area	'88 Mean	'89 Mean	T	Prob.
Math Total	127.9231	138.7692	-10.06	0.000
Concept Dev.	131.9231	143.4231	-5.35	0.000
Prob. Solving	127.8077	138.8846	-7.11	0.000
Comp. Skills	124.0769	133.6923	-7.62	0.000

Table 6
5th Grade - Treatment - ITBS
(N = 36)

Math Area	'88 Mean	'89 Mean	T	Prob.
Math Total	128.8333	141.5000	-9.62	0.000
Concept Dev.	133.0000	149.5556	-7.10	0.000
Prob. Solving	129.6389	141.4167	-6.76	0.000
Comp. Skills	123.9722	133.2778	-4.94	0.000

Table 7
6th Grade - Control - ITBS
(N = 41)

Math Area	'88 Mean	'89 Mean	T	Prob.
Math Total	138.8780	153.4390	-12.89	0.000
Concept Dev.	143.4634	158.6098	-8.67	0.000
Prob. Solving	138.4878	152.3659	-9.06	0.000
Comp. Skills	134.3659	148.4634	-7.72	0.000

Table 8
6th Grade - Treatment - ITBS
(N = 34)

Math Area	'88 Mean	'89 Mean	T	Prob.
Math Total	139.6765	153.0882	-9.39	0.000
Concept Dev.	145.5000	157.4118	-6.46	0.000
Prob. Solving	138.7941	150.7941	-5.75	0.000
Comp. Skills	135.0882	150.7647	-8.95	0.000

The Mathematics Measurement Instrument (MMI) was a test constructed according to the curriculum content of the classes. The text materials and the curriculum specifications were used to build items which would properly reflect what would be learned in each grade level. The test was a twelve item test with four items in each of the three sub-tests (Computational Skills, Concept Development, and Problem Solving). The test was administered as a pre-test and a parallel form was administered as a post-test.

Table 9
3rd Grade - Control - MMI
(N-46)

Math Area	Pre-test	Post-test	T	Prob.
Overall Total	5.3913	7.0435	-4.97	0.000
Comp. Skill	1.3043	2.2391	-5.97	0.000
Concept Dev.	1.7174	2.0870	-2.57	0.013
Prob. Solving	2.3696	2.7391	-1.77	0.084

Table 10
3rd Grade - Treatment - MMI
(N = 51)

Math Area	Pre-test	Post-test	T	Prob.
Overall Total	6.0980	7.6667	-6.03	0.000
Comp. Skill	1.5882	2.4510	-5.13	0.000
Concept Dev.	2.0588	2.3529	-2.05	0.046
Prob. Solving	2.4510	2.8627	-2.99	0.004

The third grade results show that both groups showed statistically significant improvement ($p<.01$) for the Overall Total and Computational Skills. Neither group, however, showed significant improvement in the Concept Development sub-test and only the Treatment Group showed significant improvement in the Problem Solving section.

Table 11
4th Grade - Control - MMI
(N = 50)

Math Area	Pre-test	Post-test	T	Prob.
Overall Total	4.46	7.72	-11.54	0.000
Comp. Skill	1.02	2.80	-12.39	0.000
Concept Dev.	2.22	3.40	-6.56	0.000
Prob. Solving	1.22	1.52	2.01	0.050

Table 12
4th Grade - Treatment - MMI
(N = 53)

Math Area	Pre-test	Post-test	T	Prob.
Overall Total	4.3585	6.5472	-8.61	0.000
Comp. Skill	1.0189	2.3019	-7.32	0.000
Concept Dev.	1.9623	3.0755	-5.86	0.000
Prob. Solving	1.3396	1.1698	1.54	0.129*

Table 13
5th Grade - Control - MMI
(N = 34)

Math Area	Pre-test	Post-test	T	Prob.
Overall Total	5.4706	5.4118	0.16	.873*
Comp. Skill	1.2647	1.3824	-0.64	0.524
Concept Dev.	2.7353	2.4706	1.16	.255*
Prob. Solving	1.4706	1.5585	-0.55	0.585

Table 14
5th Grade - Treatment - MMI
(N = 35)

Math Area	Pretest	Post-test	T	Prob.
Overall Total	5.7429	7.0857	-3.84	0.001
Comp. Skill	1.1429	2.0286	-4.63	0.000
Concept Dev.	2.7143	3.0571	-1.97	0.057
Prob. Solving	1.8857	1.9714	-0.46	0.646

Fourth grade data indicates that all but the Problem Solving section yielded significant results. Whereas, the fifth grade results were quite mixed with none of the Control Group results indicating significant change and only the Overall Total and Computational Skill section showing a significant change in the Treatment Group.

Table 15
6th Grade - Control - MMI
(N = 40)

Math Area	Pre-test	Post-test	T	Prob.
Overall Total	4.2250	6.8750	-8.35	0.000
Comp. Skill	1.5750	2.5250	-5.80	0.000
Concept Dev.	1.0000	2.0750	-5.54	0.000
Prob. Solving	1.6500	2.2750	-3.26	0.002

Table 16
6th Grade - Treatment - MMI
(N = 36)

Math Area	Pre-test	Post-test	T	Prob.
Overall Total	4.2500	5.1944	-2.69	0.011
Comp. Skill	1.6389	1.9167	-1.66	0.106
Concept Dev.	1.1667	1.7500	-2.91	0.006
Prob. Solving	1.4444	1.5278	-0.53	0.597

The Sixth grade results for the Treatment Group were mixed with the Concept Development subtest showing the only significant result. All data in the Control Group indicate significant changes.

To further clarify the relative gains of the two groups on the two instruments, a different data layout could provide additional information. The changes in the means from the pre-test to the post-test will give an indication of the relative growth of the groups. Table 17 summarizes the ITBS results for the Math Total only. It is easy to see that the two groups (Control and Treatment) showed remarkably consistent improvement. This provides confirming evidence that the students receiving the calculator treatment performed as well as the non-calculator group on this measure.

Table 17
ITBS Control/Treatment Mean Score Gain for Math Total

	Control	Treatment
3rd	7.7750	8.4490
4th	12.3921	11.9400
5th	10.8689	12.6667
6th	14.5610	13.4117

Table 18 similarly reports the changes in the means on the Overall Total score on the MMI. The results, although not as consistent as the ITBS results, also indicate comparable results between the two groups.

Table 18
MMI Control/Treatment Mean Score Gain for Overall Total

	Control	Treatment
3rd	1.6522	1.5687
4th	3.2600	2.1887
5th	-0.0588	1.3428
6th	2.6500	0.9444

DISCUSSION AND RECOMMENDATIONS

The basic thrust of this study was to show that a greater-than-usual use of the calculator in mathematics instruction in grades three through six would not hinder the student's acquisition of mathematical concepts and skills. The data displays support the conclusion that the student use of calculators did provide test results which showed comparable gains.

Due to several factors, the design of the study was not as educationally sound as it might have been. The study was designed and begun after the school year had started which prevented careful preparations and advanced selection or groupings. The classes were taken as intact groups and no further randomization was possible. 14

Secondly, the teachers selected for the treatment classes were not directed to use calculators in any specific way, although considerable time was spent with them in training on this specific calculator and with activities which were appropriate for their children. The time of use, type of activities utilized, and frequency of use was left to their discretion. In addition, the teachers in the Control group classes were not asked to change their approach in any way and it is quite possible that there were occasional calculator activities being utilized in their classrooms.

The teachers in the Treatment Group and the teachers in the Control Group were not matched in any way to account for any teacher variability. Normally, such factors as years of experience, additional training, areas of particular interest, etc. would be considered as two groups to be studied as constituted.

As a consequence, the results are even more convincing. The Treatment Groups were permitted to do considerably more with the Explorer calculator and apparently achieved as well as the other students.

This very brief study shows encouraging results for the short term. Other research suggests that the long-term gains attained through the use of calculators will significantly influence the ability of young students to gain mathematical power. Conceptual understanding and problem solving abilities should be positively effected by extensive use of the calculator. If the District is interested in accumulating further data which continues to address the calculator issue, it is recommended, therefore, that:

> RECOMMENDATION 1: The District establish a study which continues to gather data relating to the effect of calculator use on the attainment of mathematical skills and concepts.

At the end of the last school year, when the study was completed and the pilot-testing of calculators was completed, the Texas Instrument Explorer Calculators were removed from the classrooms of the participating teachers. The beginning of this school year, therefore, finds these trained teachers without these aids.

RECOMMENDATION 2: The Explorer Calculators should be obtained for the classrooms of those trained teachers to permit them to continue to provide their students with the additional educational opportunities provided by these instruments.

The College Station Independent School District has a valuable resource in the teachers that participated in the pilot-testing and development of the calculator activities. These teachers are now quite able to train their fellow teachers.

RECOMMENDATION 3: An appropriate professional development plan should be developed utilizing the trained teachers as trainers to provide training to other teachers on the proper use and integration of the Explorer Calculator activities into the mathematics program.

As more teachers are trained, the District will want to provide additional classroom sets of the Explorer Calculators for the other classrooms.

RECOMMENDATION 4: The District establish the necessary budgetary requests to provide a gradual increase in the number of available calculators until all teachers have ready, daily access to calculators.

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